Solid State Physics
Lecture 4
Simple Crystal Structures

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So, there are few Crystal Structures that are not of a fundamental type. The fundamental type of crystal structures we have already discussed in terms of Bravais lattices. There are certain crystal structures that are not fundamental, but that are very important to be discussed and understood for our clear understanding of the crystal structures or structure of solid. Now, we will discuss about that. (Refer Slide Time: 00:51)

So, now we will discuss some examples of crystal structure. (Refer Slide Time: 00:55)

The first example that we will consider is NaCl that is sodium chloride structure. You can see that at the origin we have a chlorine in this cube and here we have a sodium, here another sodium, here another chlorine. And, if we consider this at each corner of this big cube we have chlorines and also at the faces we have chlorines. So, it is a face centered cubic structure you can clearly see. But, if you consider sodium and chlorine it is interpenetrating structure; that means, we have chlorine here at the origin and the sodium comes here at the body center. So, chlorine becomes an fcc structure, sodium itself becomes another fcc structure and they are off by $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$ vector. So, the basis if we represent it using one primitive cell, then the basis would comprise 1 sodium ion and 1 chlorine ion. And, the chlorine ion is located at $(0, 0, 0)$ that is the origin and the sodium ion at $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$ that will make a primitive cell and with that cell we can represent this entire structure. Now, as we can see if we consider one sodium ion here there are 6 chlorine ions nearby. So, there are 6 nearest neighbors to this sodium ion and similarly 6 nearest sodium ions to each chlorine ion. That is what is going to that is what we are going to see. We can find of course, sodium chloride, lithium hydride, manganese oxide, magnesium oxide these compounds in this kind of sodium chloride kind of structure. (Refer Slide Time: 03:10)

Let us look at another kind of structure that is cesium chloride kind of structure you can see that cesium chloride here the cesium atoms at the corner of this cube and at the center it is chlorine. So, it is simple cubic cesium makes a simple cube, chlorine makes another simple cube, but they are off by $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$. So, it is inter penetrating simple cubic structures. And, the basis for the primitive cell that comprises one cesium ion and one chlorine ion. Cesium ion that is located at the origin and chlorine ion is located at the center of the cube that is that makes the primitive unit cell. And, you can see you can look at this chlorine ion at the center of this cube that will clearly suggest that it has 8 cesium neighbors at same distance. So, there are 8 nearest neighbors to each ion in this structure. Cesium chloride, BeCu, AlNi, CuZn, CuPd, AgMg these kind of compounds are found in cesium chloride structure. (Refer Slide Time: 04:29)

Then comes hexagonal closed pack. As the name suggests it is a hexagonal structure and it is the closest possible packing that you can imagine. There is no other packing that is closer than this, but there are other possibilities with similar kind of packing fraction; that means, as close as this hcp structure. So, the hexagonal closed pack structure it is in this plane it is a hexagon you can see this is a periodic image. So, the a lattice constant is this one, c is this one and b is this one and here you can see that at on the sorry on the top of this point you have one atom at the middle of the cell. On the top of this point at the middle of the cell we have one lattice point and on the top of this point at the middle of the cell we have one lattice point. This is the situation. So, the basis comprises one lattice point that is one atom at the origin and another at $(\frac{2}{3}, \frac{1}{3}$ and $\frac{1}{2})$. Helium, beryllium, magnesium, titanium these compounds are found in this kind of hexagonal closed packed structure. (Refer Slide Time: 05:59)

Now, let us look at diamond structure. It is a face centered cubic structure, but unlike sodium chloride structure here from the origin the other atom is at $(\frac{1}{4}, \frac{1}{4}, \frac{1}{4})$ off. So, it is not that the other atom is at the center of the body. So, we can make the basis by having one atom at $(0, 0, 0)$ and the other atom at $(0.25, 0.25 \; and \; 0.25)$ that makes the basis. And, interesting elements are found in this structure – diamond, silicon, germanium these semiconducting materials are found in this structure. This structure is very stable. You know how stable diamond is, it is very strong a material. (Refer Slide Time: 06:54)

Now, let us move on to zinc blende structure. Zinc blende is zinc sulfide nothing else, but there are other compounds found in this structure like silicon carbide, aluminium phosphide, gallium phosphide – these are also examples of this structure; well, zinc sulfide may be found in some other structure as well. But zinc blende structure is the cubic zinc blende structure that you can see here on the screen is the most stable structure for zinc sulfide. So, here we have two fcc structures and they are displaced related to one another by $(\frac{1}{4}, \frac{1}{4}, \frac{1}{4})$ unlike $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$ for sodium chloride. So, here we have the zinc atom and this one is sulfur and they are at a distance of $(\frac{1}{4}, \frac{1}{4}, \frac{1}{4})$. And, it makes regular tetrahedron with 4 nearest neighbors. So, if you consider one atom here say this sulfur atom, then it has 4 nearest neighbors that those are zinc; if you consider one zinc atom here it has 4 nearest neighbor those are sulfurs and those nearest neighbors make a regular tetrahedron. That is the nature of this structure.